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Heart Rate Variability: Does it Change After RF Ablation of Reentrant Supraventricular Tachycardia?

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Abstract. ***Background*****: Following RF ablation of reentrant supraventricular tachycardia, inappropriate sinus tachycardia may occur. Local parasympathetic denervation is a possible mechanism for these rhythm disturbances. The purpose of this study was to determine the incidence of sinus tachycardia and to determine the relation between endocardial lesions at different ablation sites and alterations in autonomic tone in several different groups of patients with supraventricular tachycardia, using techniques of heart rate variability analysis.**

Methods**: The subjects of this study were 75 patients (48 women, 27 men) with a mean age of 39.99 (SD = 13.39). They underwent RF ablation of AV nodal slow pathways (40 cases), posteroseptal APs (23 cases), left lateral and right free wall APs (12 cases) because of symptomatic tachycardias. The mean sinus rate and time domain (standard deviation of RR intervals and root mean square of differences of adjacent RR intervals) and frequency domain (low frequency, high frequency and low frequency/high frequency ratio) analyses of heart rate variability were obtained by use of 24 hour Holter monitoring before and 1 month after ablation compared with pre-ablation values.**

Results**: Analysis of 24 hour ambulatory Holter-monitors, performed 1 month after RF ablation, showed no significant changes in time and frequency domain parameters of heart rate variability in different groups. A significant increase in mean heart rate was noted after RF ablation at AV nodal slow pathway group and left freewall/right free wall accessory pathways group. Patients undergoing RF ablation of right or left posteroseptal accessory pathways had no significant increase in the mean heart rate.**

Conclusion**: In summary, an increase in sinus tachycardia may be initiated by RF ablation of atrioventricular reentrant tachycardia (AVNRT) and right free wall or left free wall accessory pathways. This finding shows that the modifications of heart rate are not directly related to the posteroseptal region or to the accessory pathways.**

Key Words. **radiofrequency ablation, mean heart rate, heart rate variability**

Introduction

Radiofrequency catheter ablation of atrioventricular nodal reentrant tachycardia and accessory pathway–mediated reciprocating tachycardia is currently recommended as the treatment of choice in patients with symptomatic sustained tachycardia [1]. An increase in sinus rate has been reported as a complication after RF ablation of slow pathways or posteroseptal accessory pathways (APs) [2], and parasympathetic denervation has been implicated in its occurrences [3–5]. Presence or absence of parasympathetic denervation may depend on the site of RF energy delivery [5].

The purpose of this study was to evaluate the incidence of increase in sinus rate and its duration as well as to determine the relation between endocardial lesions at different ablation sites and alterations in autonomic tone in several different groups of patients with supraventricular tachycardia, using techniques of heart rate variability analysis.

Methods

Patients

The study comprised 75 consecutive patients (48 women, 27 men) with symptomatic supraventricular tachycardia who had been referred for electrophysiological study or catheter ablation. The mean age was 39.99 (SD = 13.39) years. Of these, 40 (53%) had typical atrioventricular nodal reentrant tachycardia, 14 (19%) had a right posteroseptal accessory pathway, 9 (11%) had a left posteroseptal accessory pathway, 10 (13%) had a left lateral accessory pathway and 2 (3%) had a right free wall accessory pathway.

All patients gave written informed consent to undergo the procedure. The protocol of the study was approved by the ethics committee of the hospital. Patients with structural heart disease,

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coronary artery disease or diabetes were not included in the study.

Electrophysiological Study and Ablation

Following discontinuation of all antiarrhythmic medications for at least 48 hours before the study, each patient underwent a standard diagnostic electrophysiological study before RF ablation. Four 6 Fr quadripolar electrode catheters were introduced percutaneously into the femoral and subclavian veins and positioned at the high right atrium, His-bundle region, right ventricular apex and coronary sinus for recording and stimulation. Mapping and RF ablation were performed using a steerable 7 Fr quadripolar catheter with a 4 mm tip and 2 mm interelectrode spacing. RF current was delivered by a 500 KHz generator (Attakr II, Medtronic Inc., MN, USA) at a constant preset electrical power (30–50 W) between the distal electrode and a large patch electrode on the posterior thorax as the indifferent electrode. The time of energy application varied between 30–60 seconds. The AV node slow pathway was mapped using a combination of an anatomic and electrogram mapping approach, the anatomic location of accessory pathway was determined using the earliest ventricular activation during preexcitation and/or the site of earliest atrial signal during retrograde pathway conduction. A successful RF ablation procedure was defined as one that rendered supraventricular tachycardia non inducible in the basal state or under infusion of Isoproterenol and abolished evidence of preexcitation and retrograde conduction through the pathway.

Holter Monitoring and Heart Rate Variability Analysis

Ambulatory 24 hour ECG recording was performed the day before and 1 month after RF ablation using a 2-channel tape recorder (Novacor system). The patients were not on medications including beta-blockers, calcium channel antagonists, digoxin and antiaarhythmic drugs at the time of each Holter recording. The mean sinus rate was derived from the mean RR intervals (after the exclusion of abnormal beats) and the maximal sinus rate was derived from the maximal HR. Inappropriate sinus tachycardia was defined as a resting mean sinus rate of >100 bpm without physiological or hemodynamic causes.

The frequency domain indices and time domain indices of HRV were analyzed using the Novacor system (Rueil-Malmaison, France) employing the HRV software version 1.16.1.For the frequency domain indices of HRV, a low-frequency component (LF) defined as the power from 0.04 to 0.15 Hz and a high frequency component (HF) defined as the power from 0.15 to 0.40 Hz were calculated hourly by means of fast fourier transformation of the RR intervals. For the time domain indices of HRV, standard deviation of NN intervals (SDNN) and the proportion of adjacent RRs with more than a 50 msec difference (pNN50), were calculated for 24 h.

The pNN50 and HF are known to reflect the activity of the parasympathetic nervous system and LF/HF ratio is interpreted to be a marker of sympathovagal balance [7].

Statistical Analysis

Data are presented as mean ±SD. Differences between groups were analyzed using the paired *t*-test. A P value <0.05 was considered statistically significant.

Results

The patients were divided into 3 groups based on the target site of the ablation: AV nodal pathway group ($n = 40$), septal accessory pathway group ($n = 23$), left free wall ($n = 10$) or right free wall accessory pathway group ($n = 2$). RF ablation procedure was successful in all 75 patients. There was no procedure–related complications.

The day after the procedure, the mean heart rate increased to 89.8 ± 13.8 (range 68–140, $p = 0.001$). Inappropriate sinus tachycardia, defined as a resting mean heart rate greater than 100 beats·min^{-1} was observed in 19 patients (27.7%).

One month after RF ablation, mean heart rate was increased significantly from 76.99/min ± 12.08 to 80.27/min ± 12.5 in all four groups ($p = 0.005$).

In the AV nodal pathway group, the mean heart rate was significantly changed 1 month after ablation (81.47 ± 13.47) as compared with the preablation level (76.45/min ± 11.36) ($p = 0.004$). There was no statistically significant attenuation of SDNN ($p = 0.074$), pNN50 ($p = 0.478$), low-frequency ($p = 0.603$), high-frequency ($p = 0.372$) and LF/HF ratio ($p = 0.170$).

Patients undergoing RF ablation of right or left septal accessory pathways had no increase in the mean heart rate (80.38 ± 12.55 vs. 79.26 ± 10.55 $p = 0.73$). None of the changes in time and frequency domain indexes of HRV after RF ablation achieved statistical significance.

Patients who had left lateral or right free wall accessory pathway ablation were found to have significant increase in mean heart rate after

Table 1. *Changes in time domain indexes of heart rate variability*

	Before Ablation	After Ablation	p Value
AV Nodal pathway ($n = 40$)			
Mean NN	76.45 ± 11.36	81.47 ± 13.47	$p = 0.004$
SDNN (ms)	107.28 ± 26.82	135.75 ± 97.89	$p = 0.074$
pNN50 (%)	7.49 ± 7.68	8.30 ± 8.78	$p = 0.478$
Left Posteroseptal AP ($n = 9$)			
Mean NN	82.22 ± 7.29	81.33 ± 6.29	$p = 0.302$
SDNN (ms)	120.56 ± 40.42	128.56 ± 40.93	$p = 0.610$
pNN50 (%)	7.41 ± 8.05	8.89 ± 6.27	$p = 0.590$
Right Posteroseptal AP ($n = 14$)			
Mean NN	78.57 ± 5.11	77.93 ± 12.62	$p = 0.830$
SDNN (ms)	119.43 ± 34.288	143 ± 30.40	$p = 0.007$
pNN50 (%)	13.16 ± 13.24	15.70 ± 10.29	$p = 0.213$
Left free wall ($n = 10$) & Right free wall ($n = 2$)			
Mean NN	73 ± 13	78 ± 9.88	$p = 0.027$
SDNN (ms)	127.92 ± 37.55	140.83 ± 30.40	$p = 0.159$
pNN50(%)	16.87 ±12.52	13.85 ± 8.11	$p = 0.159$

AP = accessory pathway
All values are expressed as mean ± SD

Table 2. *Changes in frequency domain indexes of heart rate variability*

	Before ablation	After ablation	*p* Value
AV node pahway ($n = 40$)			
LF (ms^2)	645.50 ± 484.49	665.98 ± 449.30	$p = 0.603$
HF (ms^2)	257.25 ± 321.02	225.85 ± 239.69	$p = 0.372$
Right Posteroseptal AP ($n = 14$)			
LF (ms^2)	958.93 ± 601.04	1062.68 ± 685.85	$p = 0.218$
HF (ms^2)	418.07 ± 506.52	540.43 ± 582.84	$p = 0.032$
Left posteroseptal AP ($n = 9$)			
LF (ms^2)	830.44 ± 765.15	1556.67 ± 2040.18	$p = 0.322$
HF (ms^2)	345.22 ± 475.69	410.78 ± 450.39	$p = 0.692$
Left freewall AP ($n = 10$)			
LF (ms^2)	222.50 ± 487.30	1190.70 ± 518.89	$p = 0.655$
HF (ms^2)	364.30 ± 137.65	314.00 ± 139.91	$p = 0.116$
Right free wall AP ($n = 2$)			
LF (ms^2)	738.50 ± 709.228	749.00 ± 765.69	$p = 0.149$
HF (ms^2)	152.50 ± 116.67	163.00 ± 89.09	$p = 0.689$

All values are expressed as mean ± SD.

ablation (78/min ± 9.88, $p = 0.027$) as compared with the pre-ablation level (73/min ± 13). None of the changes in the indices of the SDDN ($p = 0.109$), pNN50 ($p = 0.159$), low frequency ($p = 0.627$), high frequency ($p = 0.136$) and LF/HF ratio ($p = 0.292$) had a significance in this group. Changes in time domain and frequency domain indices of HRV are listed in Tables I and II.

Mean RF ablation time was 24.61 ± 21.8 min. An increase in sinus rate was not related to the radiofrequency application time.

Discussion

Sinus tachycardia is frequently noted after RF ablation for supraventricular arrhythmias. A change in autonomic tone has been the most likely explanation for increase in sinus rate post RF ablation, it could be secondary to sympathetic stimulation or local release of adrenergic neurotransmitters or to vagal withdrawal [2,6]. A few papers have reported alteration of heart rate variability together with increased heart rate [3,6–8].

Changes in the autonomic tone have been described after ablation in different subgroups of patients [3,6–8]. Most of these studies have used HRV to assess the level of autonomic tone and have suggested that a parasympathetic withdrawal occurred, which was attributed to interruption of vagal fibers destined to innervate sinus node [3]. HRV assesses the total sympathovagal balance and its components, but it cannot be restricted to any particular neural circuit [9]. Radiofrequency induced lesions may not only directly interrupt anatomically distinct neural fibers, but also activate or inhibit reflex circuit as well [7].

However, some authors have found the absence of significant changes in heart rate variability after slow pathway ablation of AVNRT and/or accessory pathway. Purerfellner et al., have shown that RF ablation of the slow pathway in AVNRT dose not change parameters of heart rate and heart rate variability significantly by means of serial 24 hour Holter recordings [10]. Madrid et al., found a low prevalence of inappropriate sinus tachycardia during the first day after the ablation procedure of atrioventricular reentrant tachycardia and of posteroseptal accessory pathways and also the lack of a difference of heart rate variability in different groups. Their results indicate that specific damage to the posteroseptal region may be responsible for these changes. The recovery of normal sinus rate, noted mostly at 3–6 months, depends directly on the fact that follow up was provided only at 3 months [4].

Kowallik et al., have shown that autonomic control of the sinus and AV nodes is preserved following successful radiofrequency ablation of AVNRT. Their results indicate that the effects of posteroseptal radiofrequency current application are not necessarily mediated by changes in the autonomic input to the AV node [11].

Other authors have postulated that the Electromagnetic field generated by radiofrequency may exert a direct effect on the sinus node [12].

In our study, time domain analysis performed on ambulatory 24 hour Holter tapes recorded 1 month after RF ablation revealed a significant increase in mean heart rate in patients with RF ablation of slow pathway and of left or right free wall. Contrary to other studies, mentioned above, in posteroseptal accessory pathways group no increase in the mean heart rate was observed. The parameters of heart rate variability were not significantly decreased in patients undergoing slow pathway or accessory pathway ablation. The increase in heart rate was modest and it is therefore not surprising that HRV parameters were substantially unchanged.

There is a divergence in data between slow pathway and posteroseptal accessory pathway despite the proximity of these sites. An increase in sinus rate described in patients with AVNRT could be a sign of elimination of slow pathway conduction rather than a consequence of RF energy delivery in posteroseptal area. However, this is speculative and the precise reason for this discrepancy remains to be elucidated.

It has been postulated that increase in sinus rate may be secondary to alterations in cardiac autonomic tone. Little is known regarding the anatomy of the parasympathetic nerve supply to the heart. Postganglionic sympathetic and preganglionic parasympathic fibers combine at the base of heart to form the cardiac plexus. This plexus gives rise to nerves that make the left and right atrioventricular grooves rich in autonomic innervation. The fat overlying the atrioventricular groove contains numerous ganglia, but their specific regulatory function have not yet been determined. The application of RF energy may not only directly interrupt anatomically distinct neural fibers, but also activate or inhibit reflex cardiac circuits as well [8]. The issue is confounded by the complexity of the relationship between neural input, neurotransmitter release and sinus node pacemaker properties.

An increase in sinus rate post RF ablation does not relate to the anatomical site of ablation but rather to highly individual autonomic innervation patterns.

In summary, an increase in sinus rate may be initiated by RF ablation of AVNRT and right free wall or left free wall accessory pathways. This finding shows that the modifications of heart rate are not directly related to the posteroseptal region or to the accessory pathway. An increase in sinus rate post RF ablation of AVNRT and non-posteroseptal APs may reflect mechanisms other than altered autonomic tone, it could related to locally released peptides or to alterations in the receptor/endings of cardiac nervous system fibers [13]. The absence of a difference of heart rate variability indices in our different groups may depend on the fact that Holter monitoring was provided only 1 month after ablation.

Study Limitation

This study has the following potential limitations: We did not perform 24 h ambulatory monitoring ECG on the day of the ablation, therefore we could not see the acute changes in heart rate variability. Our results could show that the changes in heart rate variability recovered at 1 month after ablation, indicating a transient dysfunction of autonomic nervous system.

It involves a small number of patients in accessory pathway groups and the results therefore need to be confirmed in a larger group.

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